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SHORT COMMUNICATION

Profiling bioactive flavonoids and carotenoids in select south Indian spices and nuts

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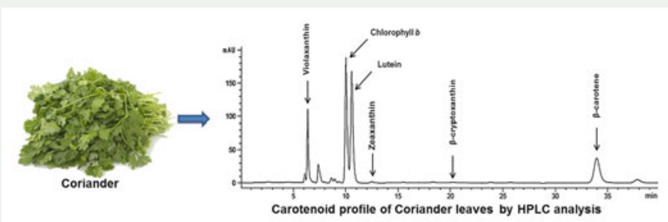
ABSTRACT

The objective of this study was to examine the bioactive flavonoids and carotenoids concentration in fifteen south Indian spice and two tree nut species using high performance liquid chromatography (HPLC). Among four flavonoids, catechin concentration was the highest in all spices and nuts and ranged between 97.1 and 1745.4 µg g^{-1}. Quercetin concentration was the greatest in cinnamon, followed by garlic and cumin and ranged from 0.4 to 65 µg g^{-1} in other spices and nuts. Lutein concentration ranged from 0.1 to 102.8 µg g^{-1}. Of the spices and nuts studied, β-carotene concentration was highest in coriander leaves (74.7 µg g^{-1}), followed by red pepper (12.5 µg g^{-1}) and curry leaves (8.5 µg g^{-1}). This research shows that consumption of south Indian spices and nuts could substantially benefit consumers living in regions experiencing Vitamin A and other micronutrient deficiencies.



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KEYWORDS
Carotenoids; flavonoids; food composition; HPLC; spices; nuts

1. Introduction

Spices are common food additions and used as flavoring, seasoning, coloring agents and preservatives across the world for more than two thousand years in South East Asian countries (Srinivasan 2005). Flavonoids are the most abundant natural products

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Table 1. Mean flavonoids and carotenoids concentration of selected south Indian spices and nuts analyzed by HPLC.

Sl. No.	Common name	Flavonoid concentration (μg g^{-1} dry weight)*					Carotenoid concentration (μg g^{-1}dry weight)*					
		Catechin	Myri.	Quer.	Kaemp.	TF§	Viol.	Lutein	Zeaxa.	β-crypto.	β-carot.	TC†
	Spice/Herb											
1.	Cumin	661.1^{g}	ND	101.2^{c}	48.2^{a}	810.5^{f}	ND	2.5^{e}	ND	ND	2.5^{d}	5.0^{f}
2.	Indian mustard	452.1^{i}	ND	ND	ND	452.1^{j}	ND	8.3^{c}	ND	ND	ND	8.3^{d}
3.	Cloves	1442.6^{c}	ND	ND	ND	1442.6^{c}	ND	ND	ND	ND	ND	ND
4.	Fenugreek	1459.5^{b}	ND	4.9^{g}	6.8^{d}	1471.2^{b}	ND	3.8^{d}	1.6^{b}	ND	ND	5.4^{e}
5.	Small cardamom	281.8^{k}	18.6^{e}	4.9^{g}	8.7^{c}	314.0^{l}	ND	2.4^{e}	ND	ND	0.5^{e}	2.9^{g}
6.	Turmeric	138.4^{m}	5.8^{g}	ND	34.0^{b}	178.2^{m}	ND	ND	ND	ND	ND	ND
7.	Black pepper	410.2^{j}	56.1^{b}	13.5^{f}	ND	479.8^{i}	ND	2.6^{e}	ND	ND	1.5^{de}	4.1^{e}
8.	Tamarind	517.9^{h}	20.4^{d}	2.5^{h}	ND	540.8^{h}	ND	ND	ND	0.3^{b}	ND	0.3^{h}
9.	Red pepper	1103.8^{d}	107.8^{a}	19.7^{e}	4.5^{e}	1235.8^{d}	ND	ND	ND	0.2^{b}	12.5^{b}	12.7^{c}
10.	Cinnamon	1746.4^{a}	ND	701.0^{a}	ND	2447.4^{a}	ND	0.5^{g}	ND	ND	ND	0.5^{h}
11.	Curry leaf	925.6^{e}	ND	65.0^{d}	0.1^{g}	990.7^{e}	ND	30.1^{b}	ND	ND	8.5^{c}	38.6^{b}
12.	Coriander, seed	97.1^{n}	ND	ND	0.3^{g}	97.4^{o}	0.9^{b}	ND	ND	ND	2.1^{de}	3.0^{g}
13.	Coriander, leaves	98.2^{n}	4.6g	0.4^{i}	1.0^{f}	104.2^{o}	41.2^{a}	102.8^{a}	1.8^{a}	0.8^{a}	74.7^{a}	221.3^{a}
14.	Garlic	168.4^{l}	8.4^{f}	246.2^{b}	ND	423.0^{k}	ND	0.1^{g}	ND	ND	0.1^{ef}	0.2^{h}
15.	Ginger	757.9^{f}	35.5^{c}	ND	ND	793.4^{g}	ND	0.2^{g}	ND	ND	0.5^{e}	0.7^{h}
	Nuts											
16.	Cashew nut	129.5^{m}	ND	2.1^{h}	0.0	131.6^{n}	ND	1.2^{f}	ND	ND	ND	1.2^{h}
17.	Almonds	102.9^{n}	ND	4.6^{g}	0.1^{g}	107.5^{o}	ND	ND	ND	ND	ND	ND
	Average	616.9	15.1	68.6	6.1	707.1	2.5	9.1	0.2	0.1	6.1	17.9
	SE‡	1.43	0.33	0.50	0.08	2.34	0.01	0.06	0.01	0.01	0.25	0.34

Note: Myri., Myricetin; Quer., Quercetin; Kaemp., Kaempferol; TF, Total flavonoid, Viol., Violaxanthin; Zeaxa., Zeaxanthin; β-crypto., β-cryptoxanthin; β-carot., β-carotene; TC, Total carotenoid.
*Within a column, means followed by different letters differed significantly according to Duncan's Multiple Range Test (DMRT) $P < 0.05$.
§Total flavonoids were calculated as the sum of four individual flavonoid.
†Total carotenoids were calculated as the sum of five individual carotenoid.
‡Standard error ($n = 51$), ND, Not detectable (detectable limit, 0.5 ng).

commonly distributed in the plant kingdom. Among the flavonoids catechin, myricetin, quercetin and kaempferol are the most powerful flavonoids for protecting the body against reactive oxygen species (ROS) (De Groot 1994) and have antioxidant, anti-inflammatory and antiallergenic (Raj and Shalini 1999), anticancer and antiviral activities (Kaul et al. 1985). Lutein and zeaxanthin are macular pigments which do not have provitamin A activity, but aid in prevention of age related macular degeneration (ARMD), (Gorusupudi et al. 2017). β-carotene and β-cryptoxanthin act as precursors for Vitamin A and help protect against vision disability in humans (Snodderly 1995). Recent studies have reported the evaluation of flavonoids and carotenoids concentration in various crops (Aruna and Baskaran 2010; Muthukrishnan et al. 2014; Ashokkumar et al. 2014; Ashokkumar et al. 2015). To date, only limited research has been published on carotenoids in south Indian spices and nuts using HPLC analysis. Hence, the aim of this study was to determine the concentration of flavonoids and carotenoids from 15 south Indian spices and 2 nuts.

2. Results and discussion

2.1. Range of linearity, and accuracy

The external standards of selected flavonoids and carotenoids, their molar mass (g/mol), molecular formula and purity (%) and molecular structures are presented in

Supplementary Table S1; Supplementary Figures S1 and S2 (available online only). The linearity was examined for the authenticated four flavonoids (catechin, myricetin, quercetin and kaempferol) aaaa and five carotenoids (violaxanthin, lutein, zeaxanthin, β-cryptoxanthin and β-carotene) standards through plotting the peak area against injected amounts and good correlation of linearity was achieved. Retention time, regression equation and recovery test determined from the standards are summarized in Supplementary Table S2 (available online). Flavonoid standard peaks were simultaneously identified using UV-Vis diode array detection at 350 nm for kaempferol, 279 nm for catechin, myricetin and quercetin, and all individual carotenoids were detected at 450 nm.

2.2. Determination of flavonoid concentration

Mean flavonoid concentration of selected south Indian spices and nuts are presented in Table 1. The HPLC analysis revealed that all four flavonoids were identified in cumin, small cardamom, red pepper and coriander leaves (Table 1). Catechin concentration in almond (102.9 μg g^{-1}) was tenfold greater than that of previously reported values of seven California grown almond cultivars (9μg g^{-1}) (Bolling et al. 2010). Red pepper (107.8 μg g^{-1}) had the greatest concentration of myricetin followed by black pepper (56.1 μg g^{-1}) and ginger (35.5 μg g^{-1}) and in other spices and nuts was between 4.6 and 20.4 μg g^{1} (Table 1). An earlier report of quercetin concentration in garlic was 85 μg g^{-1} (Cao et al. 2010), which is less than half that reported in our study (246.2 μg g^{-1}). Kaempferol concentration was greatest in cumin, followed by turmeric, and small cardamom. Han et al. (2001) isolated and quantified kaempferol from fenugreek, which supports our results. A typical sample chromatogram of identified flavonoids from garlic and coriander leaves is presented in Supplementary Figure S3 (available online only).

2.3. Determination of carotenoids concentration

Mean concentration of all carotenoids are presented in Table 1. Methanol: Dichloromethane (MeOH:DCM) extract of spices and nuts chiefly contained lutein, followed by β-carotene, violaxanthin, zeaxanthin and β-cryptoxanthin (Table 1). Lutein was previously reported as the major carotenoid in curry leaves, coriander leaves, mustard, fenugreek, small cardamom and ginger (Aruna and Baskaran 2010). A typical chromatogram of the carotenoids profile of coriander leaves is presented in Supplementary Figure S4 (available online only). β-carotene concentration of coriander leaves (74.7 μg g^{-1}) in the present study was within the range of that reported by Daly et al. (2010). The present study revealed that south Indian leafy spices are rich in β-carotene, comparable with that of golden rice endosperm (1.6 μg g^{-1}) (Beyer et al. 2002).

3. Conclusion

The present study results will aid in selecting the appropriate spice or their combination that can offer nutritional or therapeutic benefits for humans. In particular, coriander leaves were found to be rich in β-carotene, greater than reported in rice, wheat, pea, chickpea, potato, cassava and papaya. Therefore, consumption of coriander leaves could be a good strategy to address the problem of vitamin A and age related macular degeneration (ARMD) deficiencies in humans, especially from developing countries. Additionally, this research shows that south Indian spices and nuts are rich in polyphenols such as flavonoids and carotenoids that might help to reduce cancer and cardiovascular problems of the rural community.

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Disclosure statement

No conflict of interest was reported by the authors.

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